

A Possible Relationship Between Total Lightning and Non-Supercell Tornadoogenesis

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Total lightning will be available from GOES-R. Until recently, ground-based measurements of total lightning were restricted to special arrays available at selected locations across the U.S. These arrays can be used to demonstrate potential applications of total lightning to forecasters. SPoRT has been involved in such an effort for many years using the Lightning Mapping Array (LMA) in Alabama. Colorado State University (CSU) operates an LMA that covers northeastern Colorado into southeastern Wyoming, within the forecast areas of the Boulder and Cheyenne National Weather Service (NWS) Weather Forecast Offices (WFOs). Working with SPoRT and CSU, data from the Colorado (CO) LMA has been available to these WFOs for over two years. One potential application of total lightning data that we speculated might be possible was in helping to diagnose non-supercell tornadoogenesis. This poster details what we have learned so far.

Total lightning at the BOU & CYS WFOs

- Began with Geoffrey Stano's visit in Apr 2013

- Visited Spring Workshops at both WFO
- Explained the concept of total lightning
- And how it is related to severe storms

- **Key is the relationship between amount of total lightning and updraft strength**

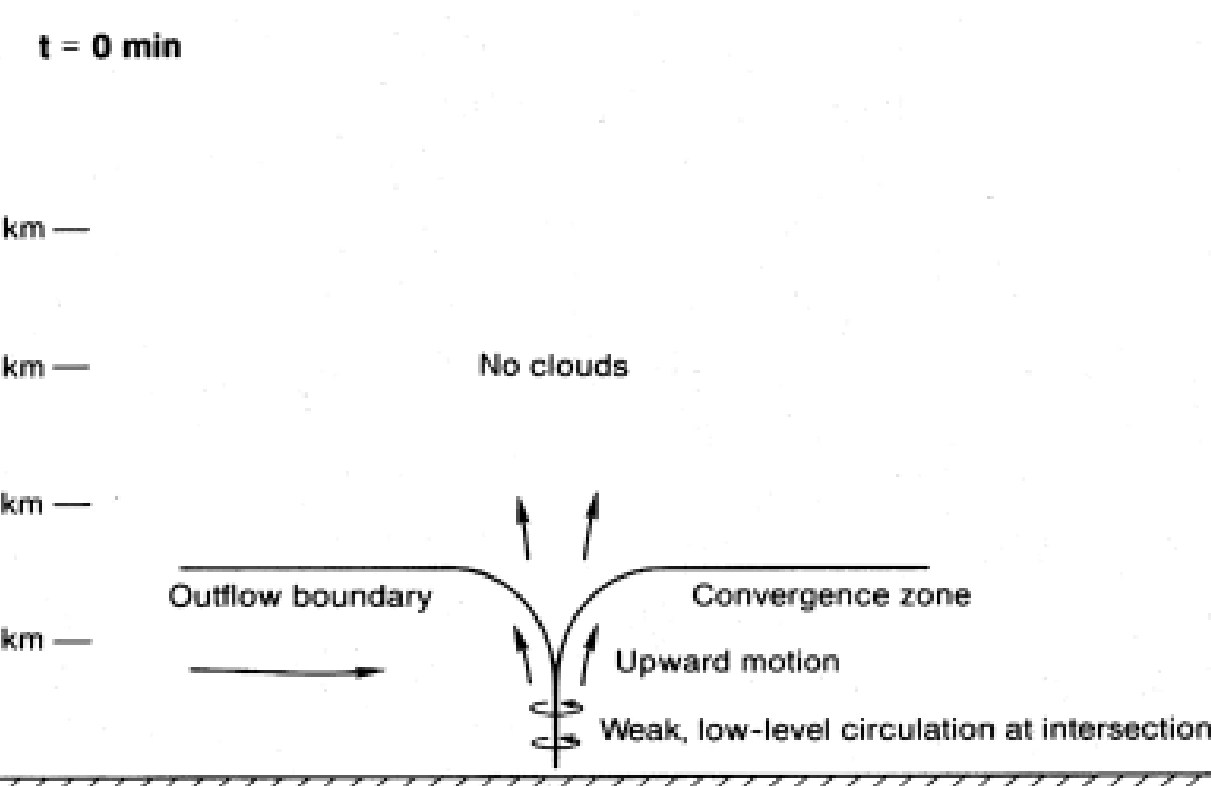
- Why single out non-supercell tornadoes?

- **Because the updraft is the key to the development of a non-supercell tornado**

- As shown by previous research – see below

How non-supercell tornadoes form:

Pre-existing stationary (or quasi-stationary) boundary present (in BOU WFO case often a Denver Cyclone boundary) along which **small-scale low-level circulations** may exist for quite a long time. Typically a collision of an outflow with this stationary boundary gets things going.

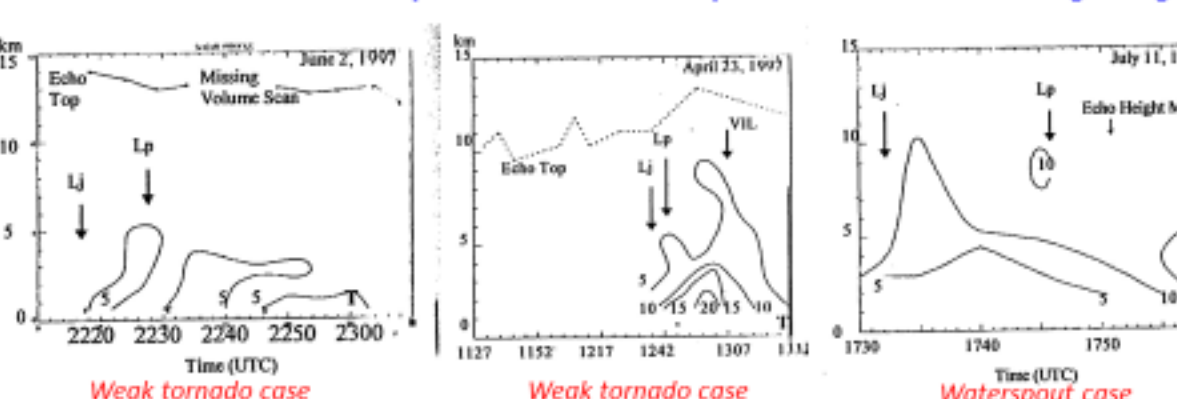


Some more landspout history

- Others had speculated on the existence of "some other" kind of tornado
- Howie Bluestein first to name it as a landspout (14th SLS Conference)
- Wakimoto and Wilson
- (many cases from CINDE in 1987)



There have been some attempts to correlate non-supercell tornadoes to total lightning



- A new study by Larry Carey (UAH) just started: M.S. student working on non-supercell tornadoes and total lightning around the northern Alabama LMA
- In a recent exchange with Chris Schultz he cited the only non-supercell tornado that he has looked at that occurred near Huntsville on 3 June 2009 - the associated cell never produced any lightning since it formed a tornado before the cloud got about the 0°C level
- Suggests regional differences likely exist

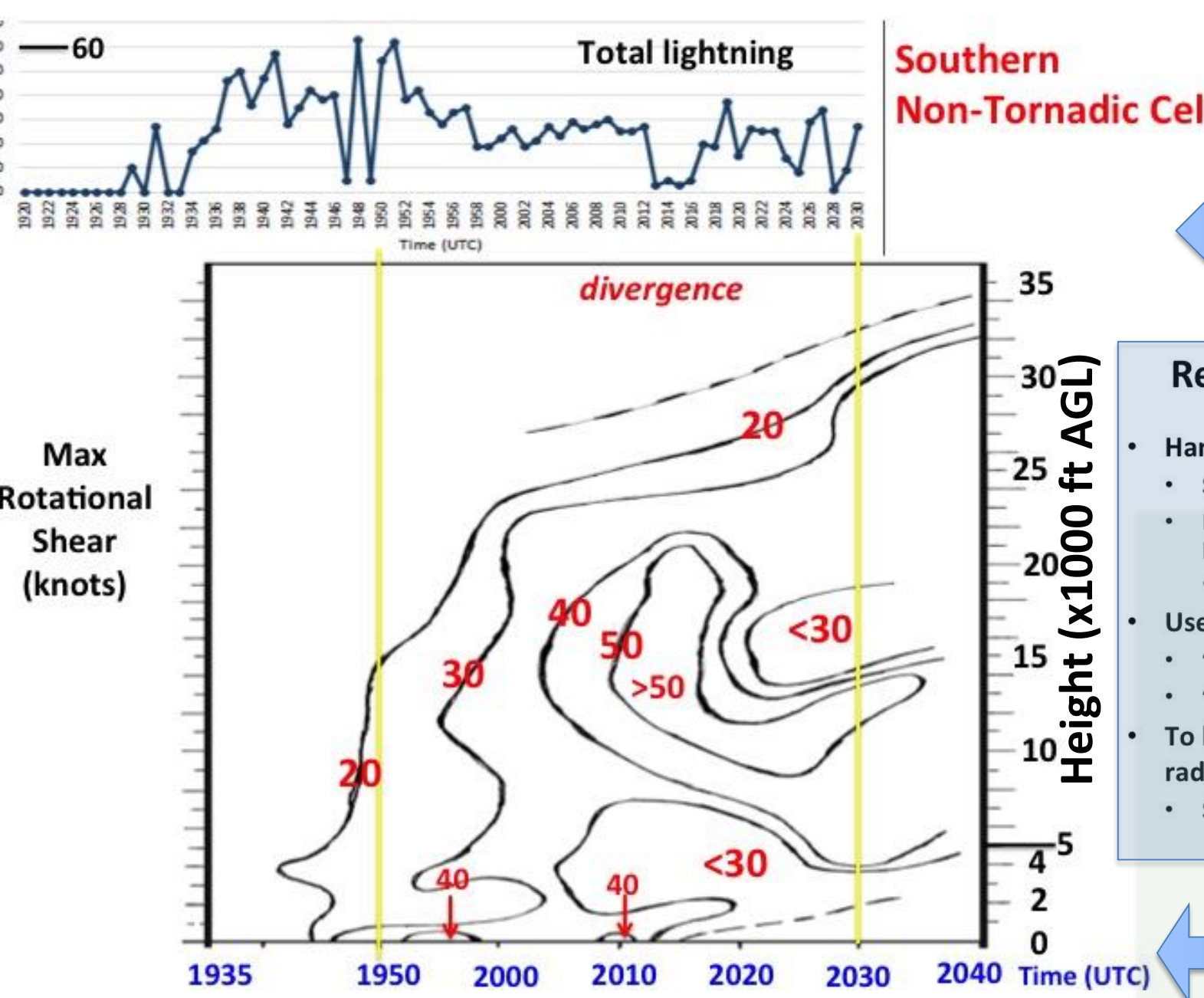
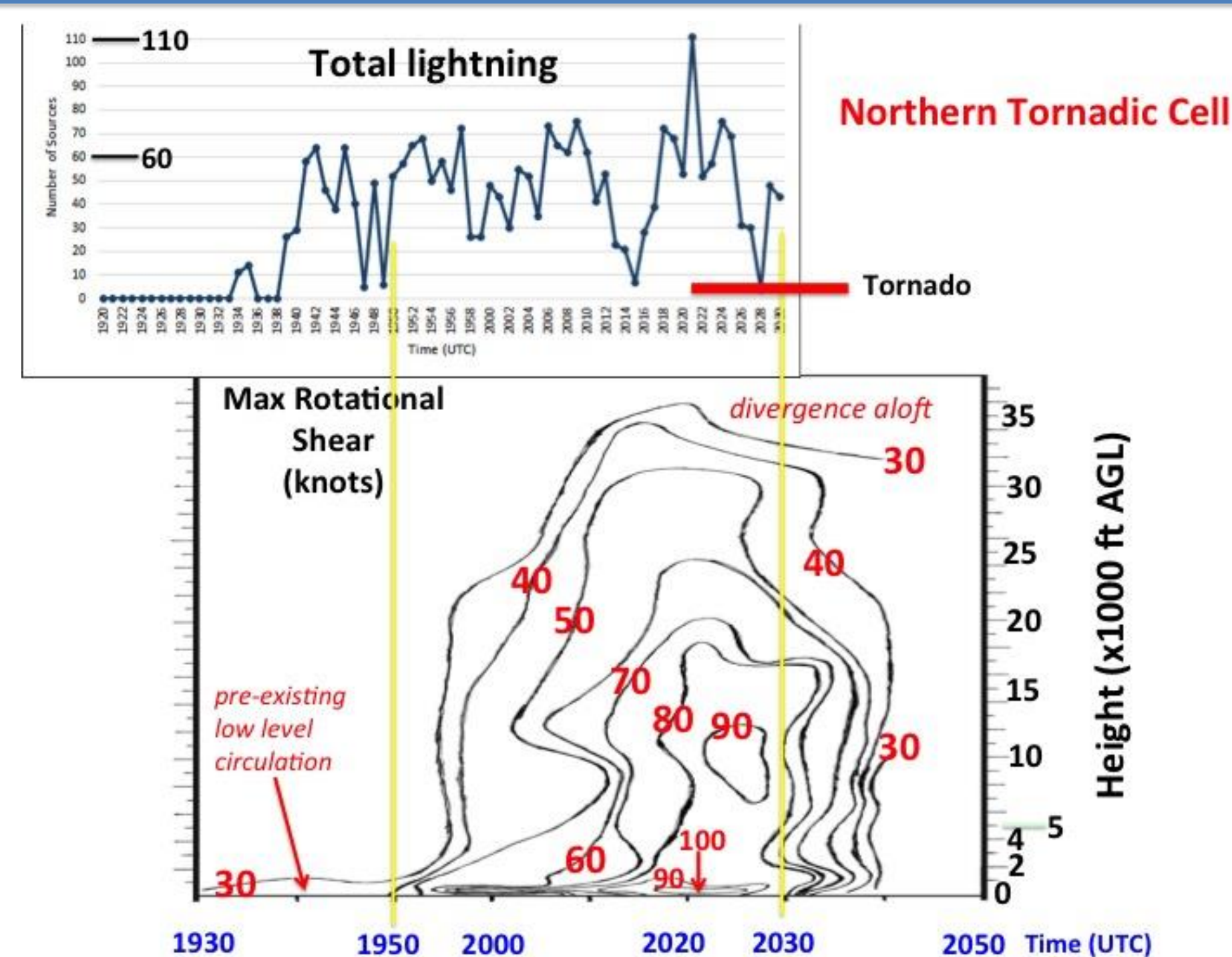
And at the NWA Conference in October:

- Lubbock TX WFO poster: "The landspout menace: An overview and streamlined process for warning operations"
- Riverton WY WFO talk: "Landspout tornadoes on weak boundaries in the basins of central Wyoming"

Still a warning problem....so trying to find any way to help is potentially useful

Above schematic is based on the study of the Erie, Colorado non-supercell tornado that occurred on 26 Jul 1985 – the first case documented with Doppler radar data (time-height results shown in this figure to the right).

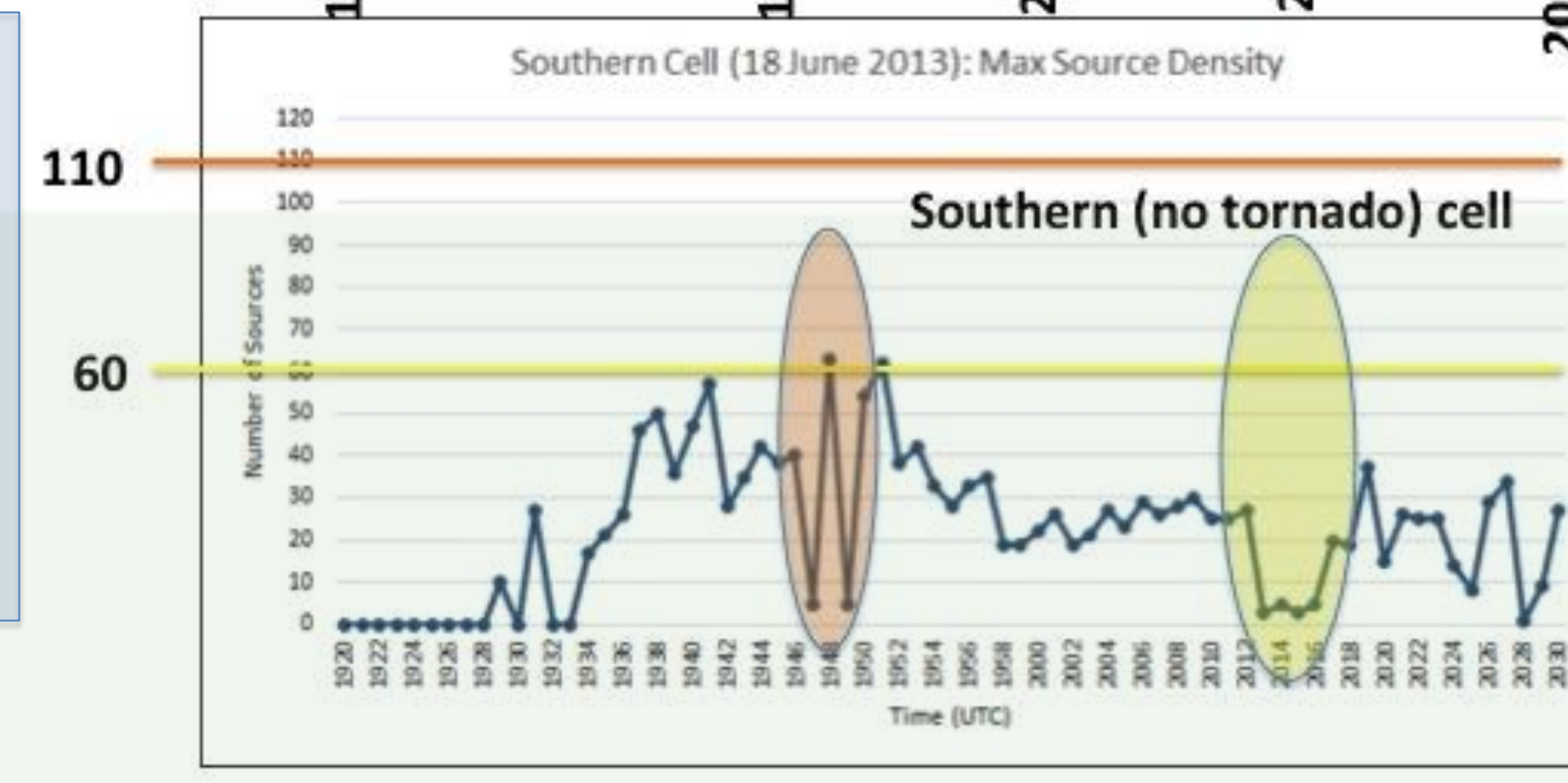
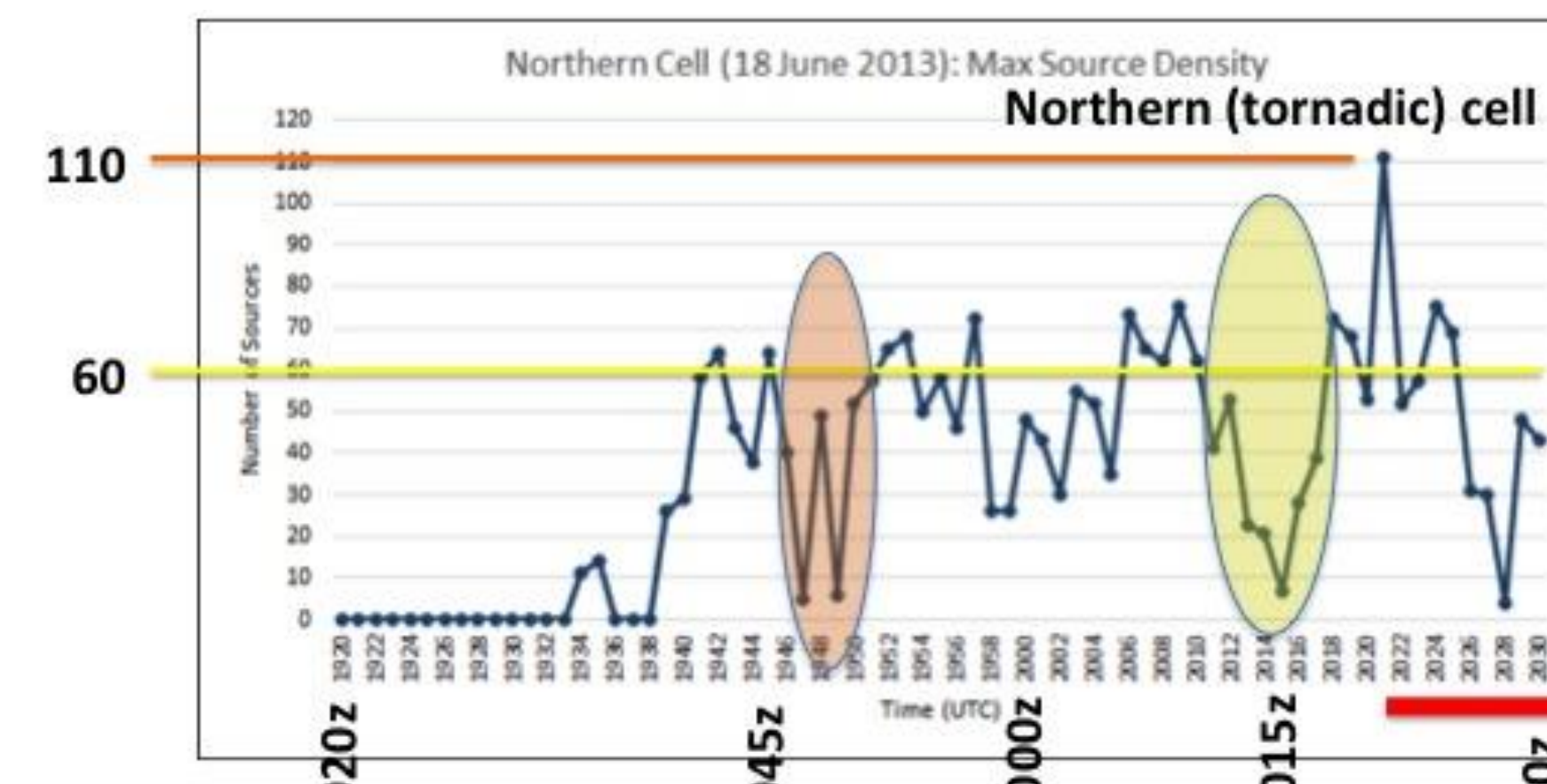
For the 18 June DIA case we construct similar time-height cross-sections (shown below)



The total lightning data for this case (provided by Geoffrey Stano) Max source density vs. Time

Reflectivity and velocity time series

- Hand gathered (forgot how slow this was) the data
- Some signals are not obvious, could be disputed
- Plotted maximum differential velocity (rotational shear) in knots and maximum reflectivity (dBZ)
- Need to calculate vorticity (not done yet)
- Used KFTG radar
- ~7 km from northern (tornadoic) cell
- ~14 km from southern cell
- To look higher into the storm used the CSU CHILL radar (thanks to Pat Kennedy for the data)
- S band Doppler, located ~35 nm north of DIA storm



What do we see:

- 1) More lightning with the tornadoic storm
- 2) High peak just prior to tornadogenesis

Are these drop-offs real? Geoffrey's take - Orange area: COLMA data glitch Yellow area: only 6 of 16 sensors were working (at least half desirable)

so...appear to *not* be real

Summary, conclusions and future work

What do we conclude from this?

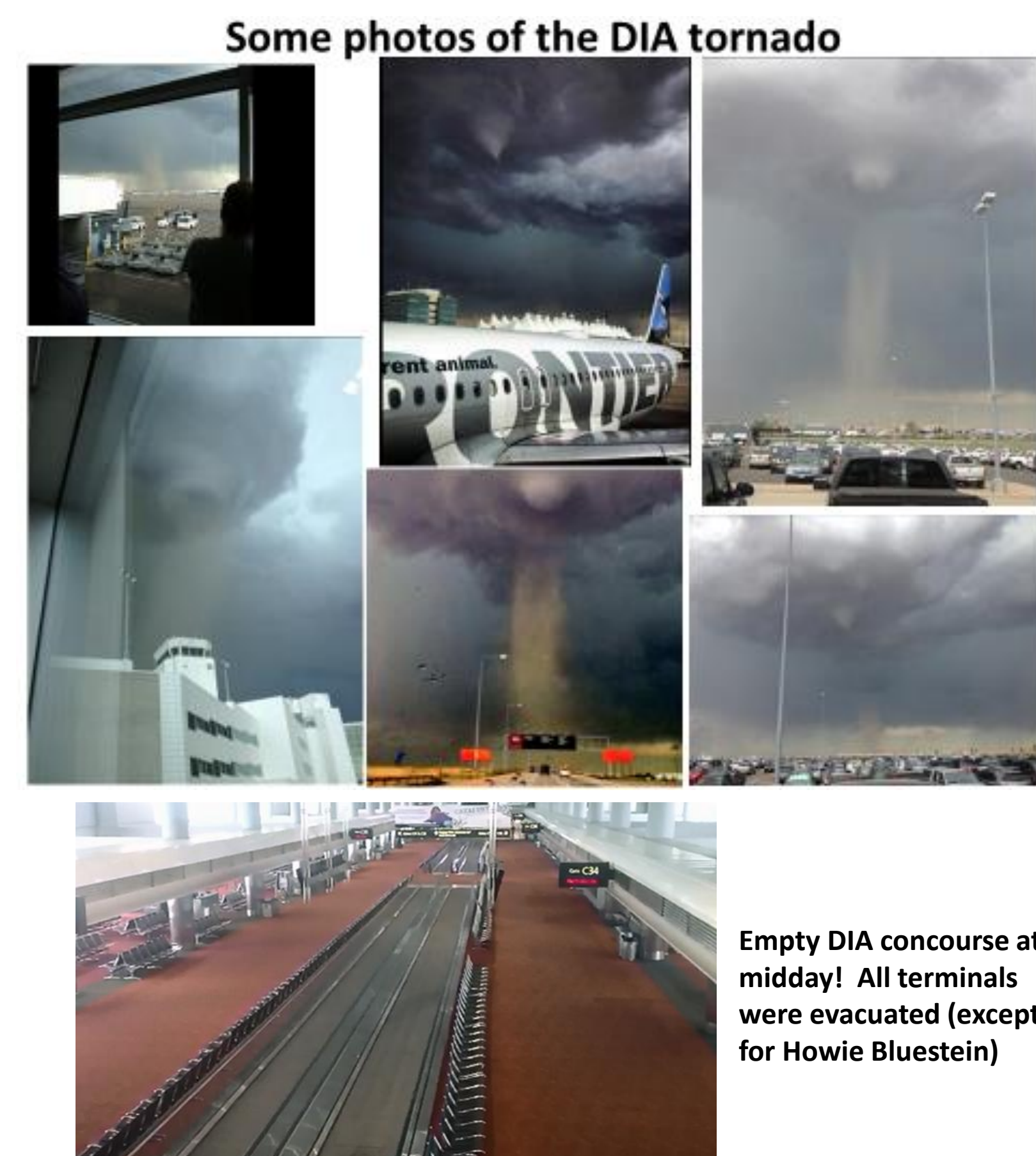
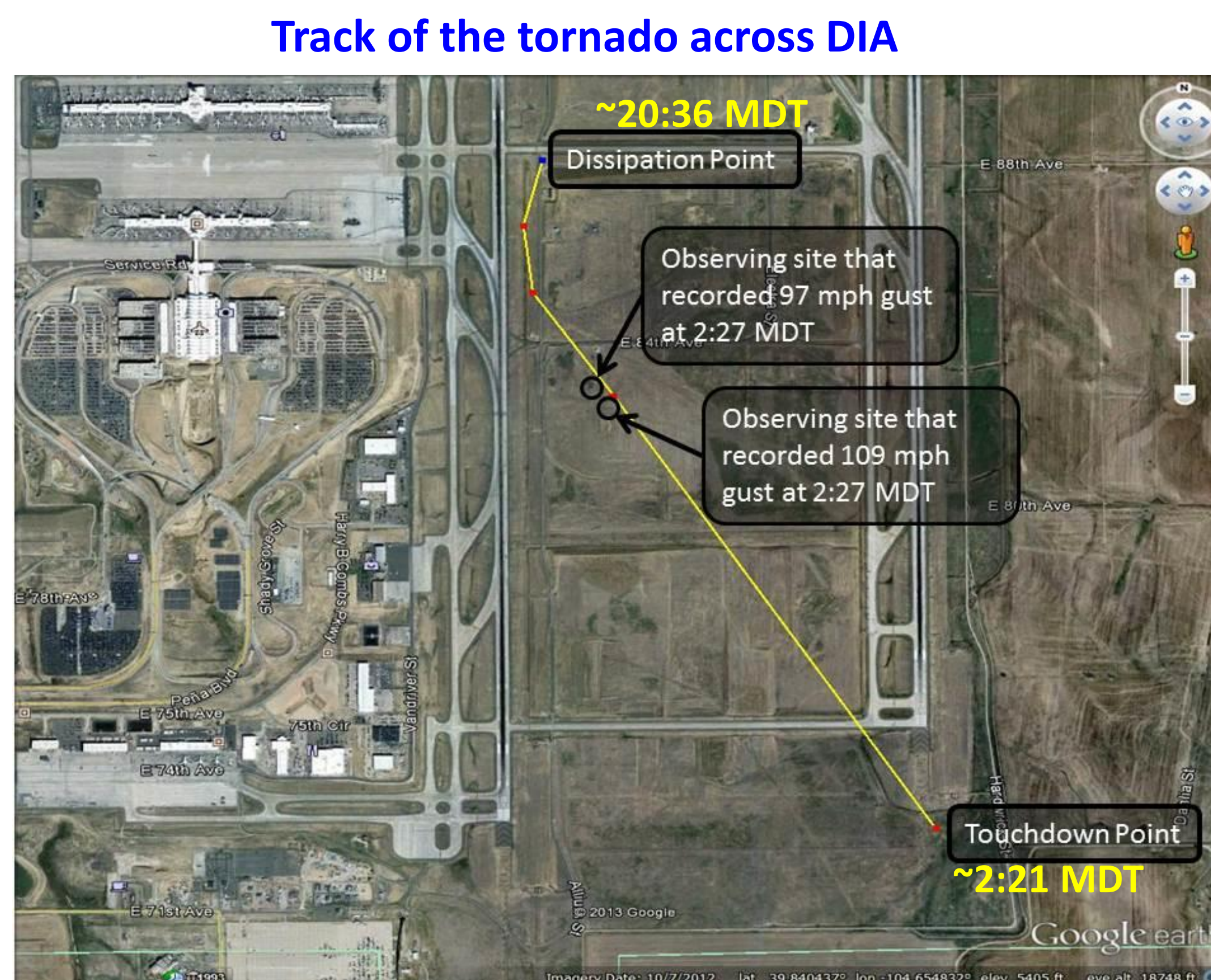
- Of course it is only one case, but
- Turned out to have both a positive and null tornadoic case
- For the non-supercell tornadoic storm max source density peaked about 2 times that for the storm that did not produce a tornado
- And in fact the tornadoic cell maintained max source density values also about 2x the null cell
- A "lightning jump" does occur with the tornadoic cell
 - But only just before the tornado forms
 - Earlier ramp ups were more modest
- Would envision using total lightning behavior as another tool to increase awareness of the potential for a non-supercell tornado
- Need to look at more storms to see if any real signal is present prior to non-supercell tornadoogenesis

And here is another case: landspout near CYS in July 2013

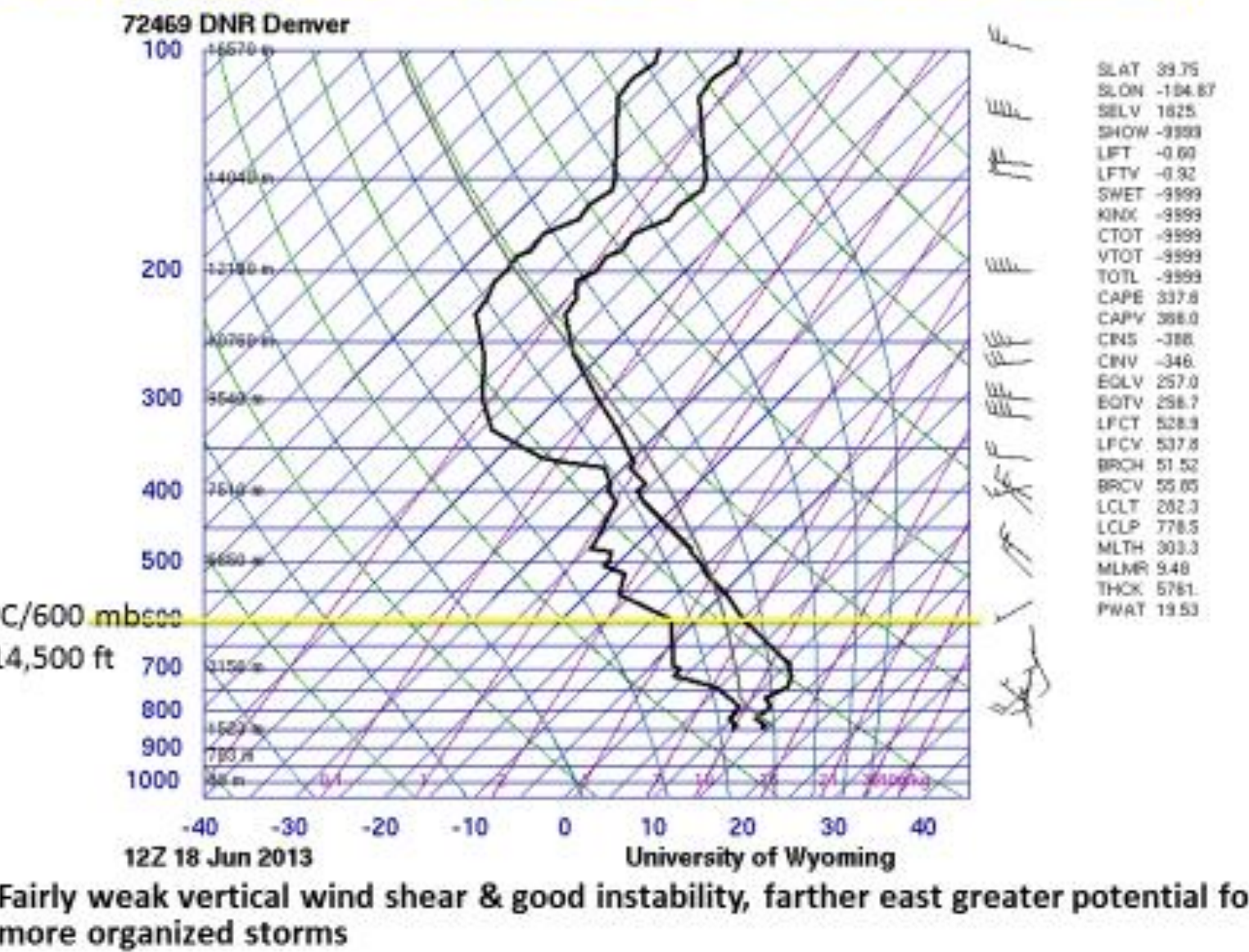


The Denver International Airport (DIA) non-supercell tornado of 13 June 2013

Excellent documentation with total lightning & radar data



Environment on 18 June 2013 – 12z Denver sounding



Set-up on 18 June: Denver cyclone surface boundary in place near DIA (good correlation with non-supercell tornadoes in June!)

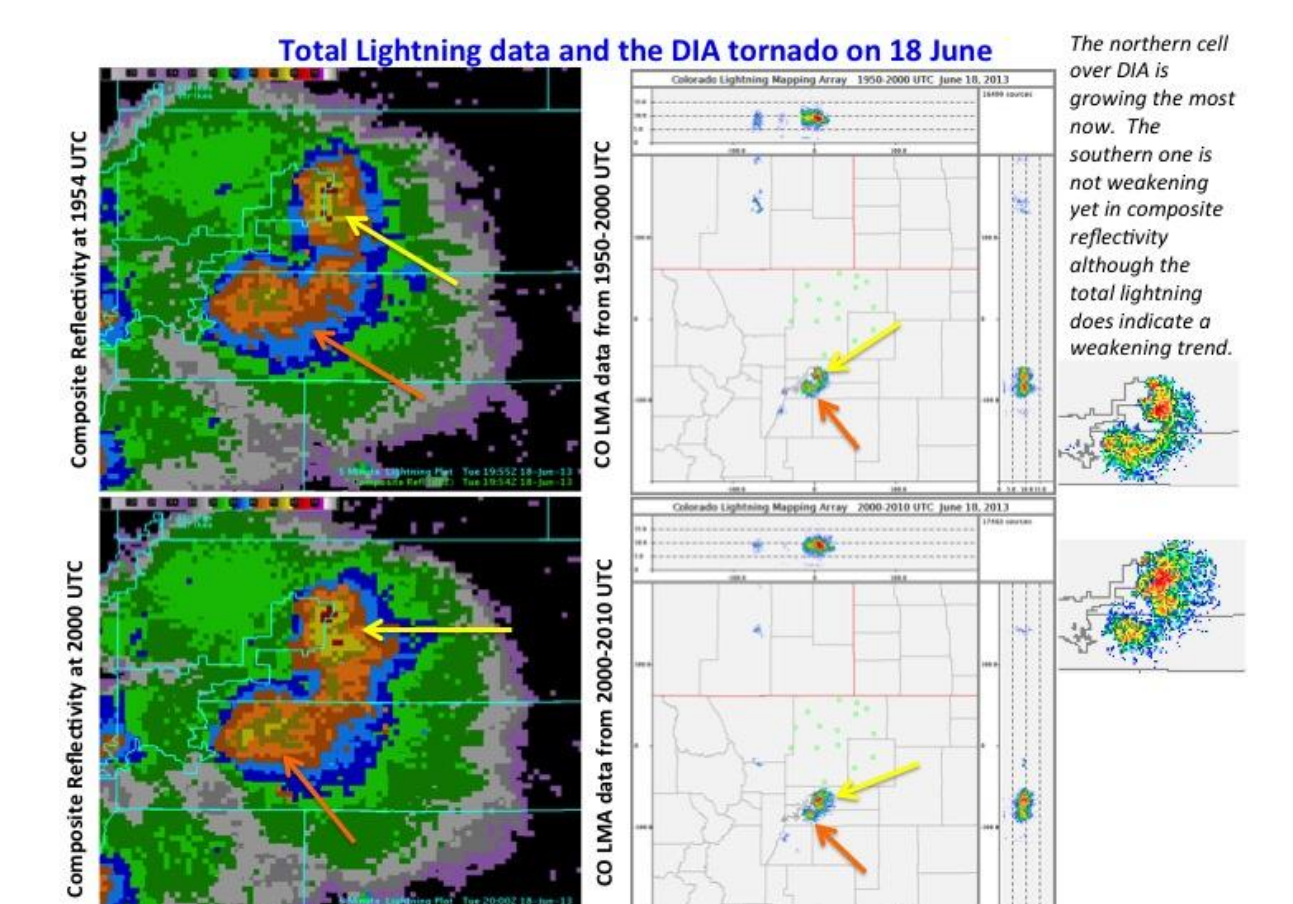
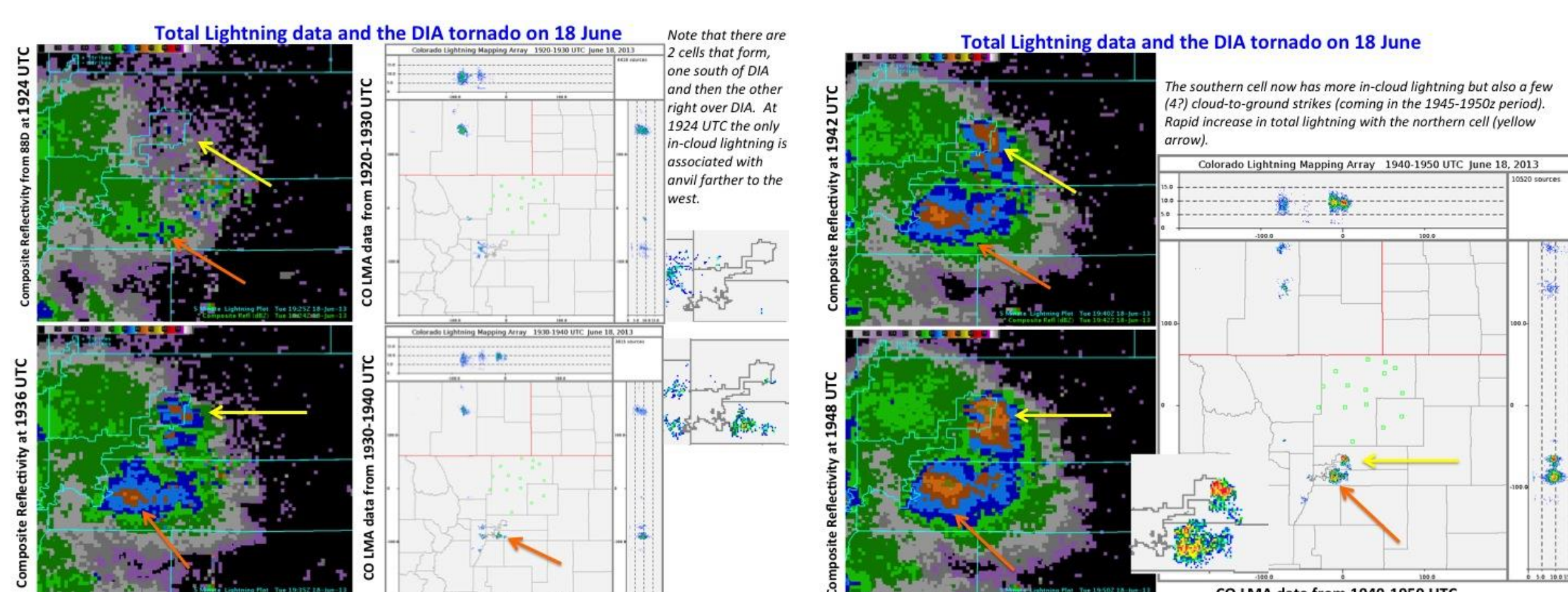
- We had good situational awareness
- I happened to be working a short-term shift at BOU on this day

From the Hazardous Weather Outlook issued at 10:50 am "IN ADDITION...A WEAK DENVER CYCLONE HAS ALREADY FORMED AND THIS SHOULD STRENGTHEN INTO THE EARLY AFTERNOON WITH THE STRONGEST CONVERGENCE RUNNING SOUTH TO NORTH NEAR DIA. **ALONG THIS BOUNDARY STORMS COULD BECOME LOCALLY MORE INTENSE WITH A NON SUPERCELL TORNADO POSSIBLE.**"

Though did hedge some in the AFD issued about an hour later

First tornado warning was issued at 2:09 pm (Bob Kleyla and Dave Barjenbruch were the warning forecasters)

What we saw in real-time: radar with CO LMA situational awareness display from CSU website



Summary:

- 2 cells at very close range to the radar, so excellent radar resolution
- Good documentation of actual tornado
- Plus a null case: one to the south did NOT produce a tornado but northern DIA one did
- Any difference in the total lightning signatures?
- Approach: compare time-height diagrams of the reflectivity and velocity for the 2 cells to time history of total lightning